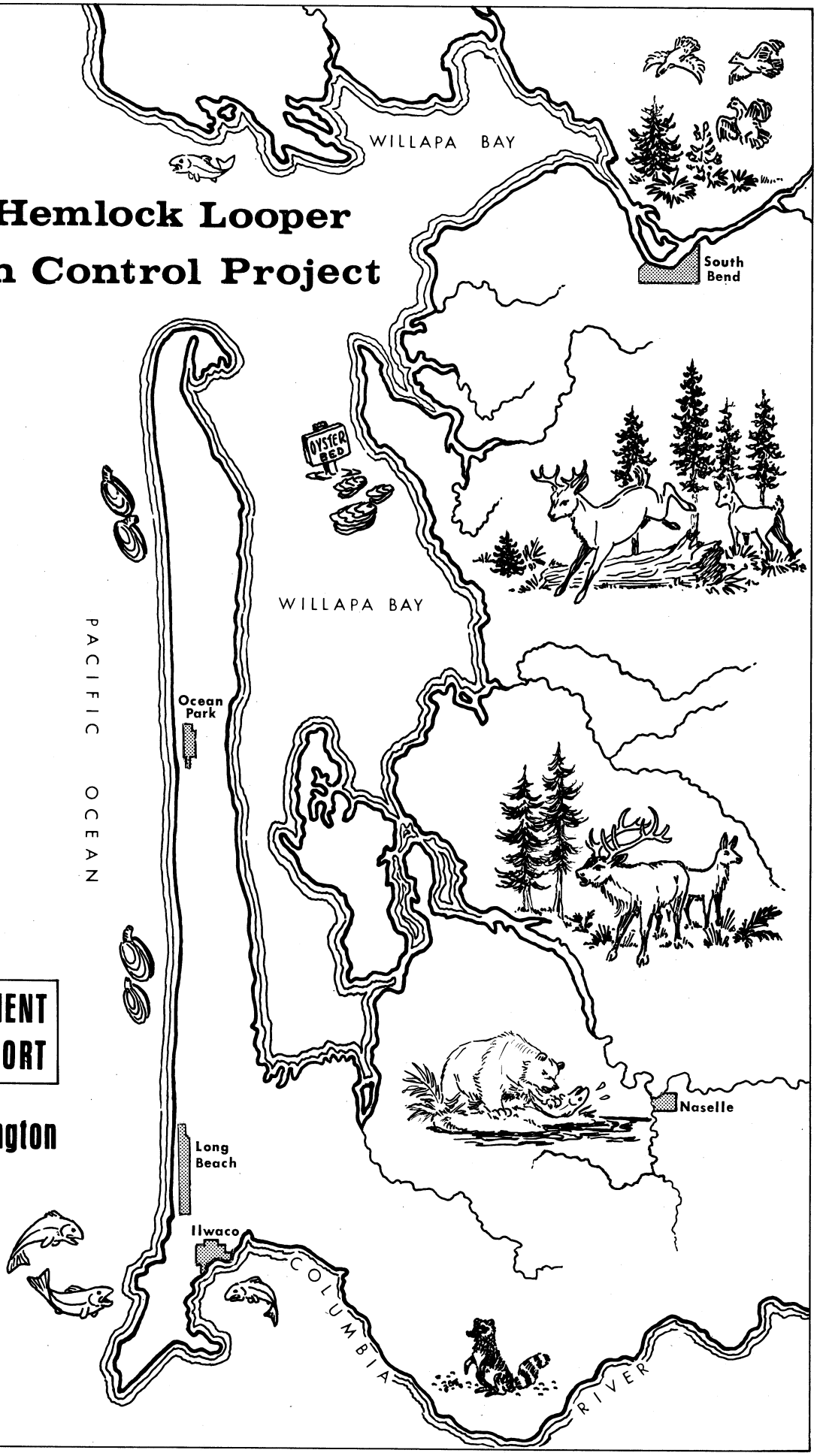
SPR 27-1

Supplement

Willapa Hemlock Looper Infestation Control Project



1966 SUPPLEMENT TO STATUS REPORT

State of Washington

1966

SUPPLEMENT TO

STATUS REPORT

1963 WILLAPA HEMLOCK LOOPER INFESTATION CONTROL PROJECT

STATE OF WASHINGTON

Prepared by: Hemlock Looper Study Committee
January, 1966.

Donald R. Hopkins, State Department of Natural Resources

Benton Howard, U. S. Forest Service

Norman E. Johnson, Weyerhaeuser Company

Alfred T. Neale, Pollution Control Commission

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INTRODUCTION

In July of 1963 the State of Washington Department of Natural Resources in cooperation with the U. S. Forest Service and private landowners initiated an aerial spray project to control a hemlock looper infestation in the Willapa Bay area of southwest Washington. The State sprayed 57,515 acres; sevin (now known as carbaryl) was used on 43,204 acres, DDT on 11,796 acres, phosphamidon on 2,276 acres, and Bacillus thuringiensis on 239 acres. Private industry sprayed 14,810 acres with DDT. Nine Federal Government agencies, 13 State agencies and 3 private timber companies cooperated in evaluation of the looper project impacts on timber and other resources. A status report[1/] issued in May, 1964 described the 1963 Willapa project and the various monitorial studies that attended it. Significant findings of the Status Report were:

1. DDT did an effective job in controlling hemlock looper; the other materials used did not.

2. There were no observed adverse effects on fish, oysters, crabs, birds or animals.

3. There was killing of newly-hatched mayfly larvae in several study streams. Mayfly numbers were normal again by the end of summer.

4. DDT levels in stream water increased from trace amounts to a high of 590 parts per trillion within several hours after spraying, but dropped to trace amounts a few hours later.

5. DDT levels increased temporarily in adipose tissue of deer and elk harvested from the spray area; two animals had values slightly above the 7 ppm tolerated in beef fat. One year later residues had returned to pre-spray levels.

This supplement to the 1963 Status Report gives the results of several studies not yet completed when the Status Report was issued. Summary statements of these supplemental studies are included in the text of the report; detail reports are in the Appendix.

1/ Copies available from the State of Washington Department of Natural Resources, Box 168, Olympia, Washington

EFFECT ON STREAM BIOTA

Stream Biota Back to Normal

Stoneflies of the family Perlidae declined in a stream sprayed with both DDT and carbaryl. This decrease in stonefly numbers and the previously reported loss of newly hatched mayflies were the only adverse effects detected by the stream biology studies. In 1964 all streams had aquatic insect populations comparable to those recorded before spraying. It is to the credit of skilled helicopter application of the pesticides that stream losses were not serious.

DEFOLIATION AND TREE KILLING

DDT Spraying Reduced Defoliation and Tree Killing

Tree mortality and defoliation counts on color photographs taken prior to the spraying in June, 1963 were compared with the photos of the same areas taken in August, 1964. Data in the following table show how DDT spraying benefited the infested stands.

Treatment	Location	1963 Photo Count of Heavily Defoliated Trees 1/	1964 Photo Count of Heavily Defoliated and Killed Trees	Percent Change
Non-sprayed control	Long Island	17	58	+241
Sevin	Sunshine Point	31	176	+468
	Sunshine Point	5	31	+520
DDT	Finn Creek	141	62	- 57

1/ No killed trees.

Heavily Defoliated Trees Continue to Die

Mortality has continued in three heavily defoliated trend plots sprayed with DDT in the North Nemah River Drainage. Of 250 tagged trees examined at yearly intervals, 27 (11%) died in 1964 and 21 (8%) died in 1965. Of the dead trees, 31 (75%) initially were over 90 percent defoliated.

On 6 plots established by the Department of Natural Resources in stands with heavy looper defoliation, 21 percent of the 240 tagged trees have died. Of these, nearly all were 90 percent or more defoliated.

DDT LEVELS

Still no DDT in Oysters

Samples collected during July, August, October and November 1964 from the mouths of the Nemah, Naselle and Palix Rivers contained, on analysis, no detectable residues of DDT or DDE.

Conclusion: There was no apparent effect on oysters from the spraying program.

Milk free of DDT

Food and Drug Administration inspectors collected 14 milk samples from Chinook and Rosburg, Washington during the period of August 1963 to January 1964. Analyses at the Seattle District Laboratories failed to reveal any residue of Sevin or DDT.

DDT Levels in Deer and Elk Drop Back to Normal

Adipose tissue from 14 deer and 12 elk killed in the spray area during 1964 contained from 0.030 to 0.440 ppm DDT. In summary, the maximum amounts of DDT in a few animals increased the

fall after spraying to levels near that tolerated in beef, but decreased within a year to prespray levels.

DDT Disappears from Sword Fern

Because of the build-up of DDT in the adipose tissue of deer and elk, sword fern--a chief food of elk--was collected and analyzed for DDT residues in order to help predict whether there would be any further cause for concern. The highest amount found was 50 parts per billion on the 1963 fronds and 24.5 parts per billion on 1964 fronds. Calculations show that this was about 1/4000 of the maximum amount estimated to be present on the fern foliage immediately after spraying.

Streams Free of DDT

DDT was not detectable in water samples collected on January 20, 1966 from the following streams:

Bear River
Finn Creek
Jim Crow Creek
Davis Creek
Clearwater Creek*

Results from all five (5) locations were negative or nil based on 50 ppt. established as the minimum sensitivity limit during the project.

EFFECTIVENESS OF SEVIN

Confirmed - Sevin not for the Loopers

Follow-up laboratory tests of insecticides again showed that carbaryl, as Sevin is now called, was not effective in controlling loopers. DDT continued to do a good job, but Guthion, Endosulfan and Pyrethrum looked good also. In laboratory tests made in California, carbaryl showed up poorly; Zectran gave excellent control.

* The Clearwater sample was collected outside of the project area, and was used as a control sample.

LIST OF PUBLICATIONS

Looper Project Generates Several Published Reports

The following reports are not included in detail in this summary or the initial publication:

Buffam, Paul E. 1965. Carbaryl, phosphamidon and DDT tests on the western hemlock looper in Washington. Jour. Econ. Entomol. 58(5): 1006-1008.

Carolin, V. M. and C. G. Thompson. Bacillus thuringiensis tested against western hemlock looper. Pacific Northwest Forest and Range Expt. Station Paper. In press.

Carolin, V. M., N. E. Johnson, P. E. Buffam and D. McComb. 1964. Sampling of egg populations of western hemlock looper in coastal forests. U. S. Forest Service Research Paper PNW-14. 13 pp.

Johnson, Norman E. 1963. Mortality of hemlock looper larvae following spraying with DDT. Weyerhaeuser Co. Forestry Research Note 55. 10 pp.

Johnson, Norman E. and Paul E. Buffam. 1965. A test of ten insecticides for controlling the hemlock looper. Weyerhaeuser Company Forestry Paper No. 6. 10 pp.

APPENDIX

AN EVALUATION OF FOREST INSECTICIDE SPRAYING ON FRESH WATER STREAM FAUNA

Charles D. Ziebell[1/] Norman E. Johnson[2/]
Alvin D. Mills[1/] William H. Lawrence[3/]

Aerial application of insecticides to control infestations of forest insects has caused mortality among fish and aquatic insect populations (13) (17) (24) (5) (10) (22). The severity of such undesirable side effects depends upon the insecticide used, application rate and care exercised conducting the spray operation. In control projects where DDT was used, mortality in fish and aquatic insect populations often occurred at application rates of one-half to one pound of active agent per acre. However, the severity of the die-offs have been extremely variable. During the 1962 hemlock looper control project in Clatsop County, Oregon, an aerial application of DDT at one-half pound per acre on approximately 32,531 acres had no apparent adverse effect on fresh-water fisheries (20). When fish mortality does occur, concurrent losses in aquatic insects can be expected (13) (24), but insect losses have been noted without fish mortality (5) (6) (8) (9) (10).

In 1963 it became apparent that the hemlock looper infestation in southwestern Washington would have to be controlled on approximately 72,000 acres of forest land. Although this was to be an operational project of major proportions, the decision was made to evaluate the effectiveness of three insecticides in controlling the hemlock looper: sevin (carbaryl) was to be applied to 43,204 acres at a rate of 1.6 pounds per acre; DDT to 26,606 acres at 0.75 pound per acre; and phosphamidon to 2,276 acres at 1.0 pound per acre.

Helicopters were to be used to achieve better control in the application of the insecticides. Forest managers in selecting helicopters for the spraying project were mindful that care must be taken to protect other resources within and adjacent to the infestation, such as--State salmon hatchery, salmon and trout spawning and rearing streams, commercial oyster fisheries, dairy farms, domestic water supplies and wildlife resources. This project was administered by the Washington State Department of Natural Resources and U. S. Forest Service in cooperation with the forest industries. Numerous State and Federal agencies participated in monitoring the project.

This report summarizes the result of a study designed principally to appraise the acute toxicity effects of the three insecticides on fresh water stream fauna.

Study streams chosen to compare effects of the three insecticides on stream fauna were located in key watersheds within the infestation area. The control stream was located in the same region but about 20 miles away. All streams were approximately the same size with flows between two and five cfs. and supported similar aquatic fauna.

Finn Creek, a tributary to the North Nemah River, and Davis Creek in the Naselle River drainage were selected to evaluate the insecticide Sevin. These two areas were later oversprayed with DDT.

Jim Crow Creek, a tributary to the Columbia River, was chosen to evaluate DDT; and Fink Creek, a tributary to the lower part of Jim Crow Creek, was selected to check phosphamidon. Clearwater Creek, north of Raymond, served as an unsprayed control.

The species of primary concern were Silver salmon, Steelhead and Cutthroat trout, and the aquatic insects on which they feed.

Sampling was done in the months of June, July and August of 1963 and again in 1964.

METHODS AND PROCEDURES

Fish Studies

To detect direct toxicity of the insecticides, 10 Silver salmon fingerlings were confined in live boxes in each of the study streams. These fish were seined from the same pools where live boxes were placed. The live boxes were made of fiberglass pipe 18 inches long and 12

1/ Aquatic Biologists, Washington Pollution Control Commission, Olympia, Wash.
2/ Forest Entomologist, Weyerhaeuser Forest Research Center, Centralia, Wash.
3/ Forest Wildlife Biologist, Weyerhaeuser Forest Research Center, Centralia, Wash.

inches in diameter. The open ends were covered with nylon bobbinet held in place with pieces of tire innertube. They were anchored to stakes driven into the stream bed and oriented so water could flow through with reduced velocities. Observations of the test fish were made before, during and for approximately one week after the spraying took place. This phase of the study was not conducted in the 1964 followup studies.

Fyke nets, designed to capture dead fish, were placed in each stream the day before spraying since the test streams could not be observed continuously.

Fish were seined from four selected pools in each stream to establish a population index. Three seine hauls made up a unit of effort for each pool. The captured fish were tallied by species and then released at the point of capture. Collections were made prior to spraying and twice afterward.

Fish traps were constructed near the mouth of the four streams to detect any outward movement of fish that might occur such as an avoidance reaction to sub-lethal concentrations of the insecticides.

Aquatic Invertebrate Studies

To detect direct toxicity, small fiberglass live boxes containing crayfish and Limnophilid caddis larvae were placed along side those containing fish. These invertebrates were collected from the same general area just prior to spraying. Observations were made prior to spraying and intermittently thereafter for approximately two weeks. These tests were conducted only in 1963.

Aquatic insect larvae and nymphs were counted periodically on tagged rocks. Aluminum identification tags were attached to each rock with monel wire. Ten tagged rocks 4" to 6" in diameter were placed in four individual riffles in each of the four streams. Counts were made prior to spray, immediately after, and intermittently thereafter throughout the summer. Most of the tagged rocks were lost during the winter of 1963-64. Consequently, in the summer of 1964, counts were made on rocks selected at random in the same riffles used in 1963.

Samples to determine the relative numbers of various insect families were collected in the upstream and downstream portions of each study stream. Collections were made in two riffles in each location. Approximately one square meter of stream bottom was agitated and insects caught in a screen net. Insects were picked from the screen and preserved in vials for later study in the laboratory. Only the prominent families, Baetidae, Heptageniidae and Perlidae were used in the final analysis.

To collect drifting insects screen nets were set up at various locations in streams. These nets were checked immediately after the spray and during the morning of the following day.

DDT Analysis

To provide adequate material for analysis approximately 180 grams of fish and 90 grams of aquatic insects were collected prior to and after spraying. Samples were frozen and shipped to the laboratory of the U. S. Department of Agriculture, Entomology Research Division, Pesticide Chemicals Research Branch in Yakima, Washington for analysis.*

RESULTS

The chronology of events will be discussed separately for each stream. Data for the major fish and insects are included in Figures 1 through 4 and Tables 1 through 3.

Clearwater Creek (Control Stream. Sec. 35, T.15 North, R. 9 W.)

Silver salmon populations dropped slightly after the first seining in 1963, but were stable the remainder of the study period. Trout populations remained relatively constant throughout. The following year, 1964, there was a gradual decrease in both Silver salmon and trout as the summer progressed (Figures 1 and 2). Silver salmon fingerlings, crayfish, and caddis larvae held in live boxes during the 1963 study survived with no ill effect.

Insect counts on tagged rocks in 1963 increased until the last check when a slight decrease was noted (Figure 3). This same pattern was indicated in the 1964 data (Figure 4).

* The specific procedures are listed in U.S.D.A. Reports numbered PCY-63-10 and PCY-65-6.

Basic trends in the stream bottom insect sampling phase were similar for both 1963 and 1964. These trends were established by using only the most prevalent families of Ephemeroptera (mayflies) and Plecoptera (stoneflies). The number of insect larvae and nymphs in other families were insufficient to establish trends (Table 1). Baetidae and Heptageniidae mayfly populations were substantial in July with gradual declines following in August and September with one exception. This exception occurred in the September, 1964 sample where Heptageniids increased rather than decreased as was the general pattern. Perlidae stonefly populations increased steadily from July through September each year.

Clearwater Creek was the coldest of the study streams, and lagged behind the other test streams in biological development of aquatic insect fauna; however, we do not feel that this seriously affects the comparison made with the sprayed streams.

Fingerling Silver salmon in 1963 and yearling Cutthroat trout in 1964 were collected and analyzed for DDT. The reason for changing species in 1964 was to use specimens that were inhabitants of the creek for the entire study period. Trace amounts of DDT were detected in the Silver salmon and a concentration of 0.019 p.p.m. was found in the Cutthroat trout sample (Tables 2 and 3). Only trace amounts were detected in aquatic insects.

Davis Creek (Sevin and DDT. Sec. 20, T. 10 N., R. 9 W.)

Fish and aquatic insect productivity in Davis Creek was lower than other test streams in 1963 even prior to spraying (Figure 3). The Davis Creek watershed was sprayed with Sevin according to plan, but was oversprayed with DDT five days later. Sevin had no apparent effect on stream organisms. All salmon fingerlings, crayfish, and caddis larvae, confined in live boxes during and following the spray, survived and were in good condition. The fish populations remained stable throughout the summer of 1963. Aquatic insect population trends followed those of the control stream in the tagged rock counts and stream bottom samples.

Again, following the DDT spraying, no dead fish, crayfish or caddis larvae were found in the live boxes. Insect counts on tagged rocks showed a noticeable decrease in the population. Losses were primarily small mayfly nymphs and blackfly larvae. These populations remained low through September 1963, which was opposite to what occurred the following year. The stream bottom insect samples indicated that total insect numbers did not decline noticeably.

Water analysis data indicated that DDT was detected in the stream for approximately 12 hours on July 25, 1963 (Figure 5). Measurable concentrations ranged from a trace to 0.0001 p.p.m. The following three days during intermittent spraying DDT was detectable in 5 of 18 samples. DDT concentrations ranged from trace amounts to 0.000075 p.p.m.

Analysis of fish tissues for DDT prior to the spray indicated a concentration of 0.017 p.p.m., as compared to 0.026 p.p.m. after spraying. The following year DDT concentrations in yearling trout were 0.013 p.p.m., much the same as pre-spray. Pre-spray samples of insects showed a concentration of DDT of .01+ p.p.m. Post-spray insect analysis for DDT residues was not conducted because of an insufficient quantity of insects in the sample collected.

Jim Crow Creek (DDT. Sec. 5, T. 9 N., R. 7 W.)

The Jim Crow Creek drainage was sprayed only with DDT and the effects of this chemical were well defined. Fish populations remained relatively constant, but aquatic insect populations showed a temporary marked decrease following the spray.

Two salmon were found dead in the live boxes, but this mortality was considered insignificant. Both specimens were frozen for DDT analysis. The concentrations found (0.20 and 0.29 p.p.m.) were deemed insufficient to have caused the deaths. No other fish mortalities were recorded. All crayfish and caddis larvae survived with no apparent adverse effects.

A definite drop in aquatic insect counts on tagged rocks was noted directly after spraying. This loss occurred primarily in first instar mayflies (pin head in size and too small to be caught in drift nets). The average number of insects was reduced from 42 to 4 per tagged rock (Figure 3).

Also, there was a marked decrease of Baetidae and Heptageniidae mayfly nymphs in the stream bottom samples. Apparently stoneflies in the family Perlidae were not harmed as population trends were similar to that of the control stream. Subsequent checks showed that tagged rocks were repopulated by other mayflies later in the season. The following year, population trends were back to what appeared normal.

On July 5, 1963 DDT was found in water samples taken immediately after spraying terminated east of the creek at concentrations of 0.000084 p.p.m. and 0.000085 p.p.m. Trace amounts of DDT were found in one sample taken after spraying ceased on July 6. No observable effect to stream fauna was detected.

DDT concentrations were higher when the area west of the creek was sprayed. Amounts ranged from a trace to 0.000570 p.p.m. on July 9 and from 0.000130 p.p.m. to 0.000590 p.p.m. on July 10. The known time span of DDT persistence in the stream was two hours on July 9 and six and one-half hours on July 10. A marked decrease of mayfly nymphs was detected after the July 10 application of DDT.

Increases in DDT were found in both fish and insects after the spraying. Pre-spray analysis of fish revealed 0.010 p.p.m., whereas post-spray analysis showed concentrations of 1.070 p.p.m. DDT. DDT in insects increased from a trace to 0.390 p.p.m. This increase was the most pronounced of all test streams. One year later fish analyzed for DDT in Jim Crow Creek yielded an average residue of 0.036 p.p.m.

Finn Creek (Sevin, DDT. Sec. 30, T. 12 N., R. 9 W.)

The evaluation of the spraying effects on Finn Creek was complicated by several incidents. First, pilot error and faulty equipment resulted in the stream being heavily sprayed with Sevin; second, the area was over-sprayed with DDT shortly afterward; and third, to further complicate matters, in the 1964 follow-up studies logging road construction along the creek caused physical changes in the stream that influenced second year results.

Silver salmon, crayfish, and caddis larvae held in live boxes during and after the spray survived with no apparent ill effects. This occurred with both the Sevin and DDT spraying operation.

Fish population studies indicated that the numbers of Silver salmon dropped considerably following the Sevin spraying and declined further following the DDT spraying; however, no dead fish were observed during this period. This was the only marked decrease indicated in any of the fish population studies. An unexplained increase in numbers of trout occurred after the Sevin spraying. The change in trout numbers may indicate that an immigration from adjacent smaller pools happened as a result of decreased stream flow. The Silver salmon decline was not evident during the follow-up studies in 1964.

Tagged rock counts, particularly mayflies, showed a marked reduction following the spraying of Sevin. Further reduction was experienced after DDT was sprayed, but numbers of insects on the tagged rocks were so low that a precise evaluation was not possible. Six weeks after the spraying had been completed a rapid recovery of small mayfly nymphs took place. Rock counts almost equalled those made prior to spraying.

Stream bottom analysis indicated that the total insect population was not harmed to the extent suggested by the tagged rock counts. The larger mayflies, both Baetidae and Heptageniidae, were fairly stable; however, there was marked decrease of Perlidae stoneflies when an increase should have taken place according to the basic trend of the control station. A normal Perlid increase trend was evident during the 1964 sampling period.

A marked decrease in Baetidae mayflies was detected in September, 1964. This decrease could not be attributed to the spray operation the previous year. Physical changes in the creek caused by the logging road construction may have been responsible for the adverse effect on this family of mayflies.

Traces of Sevin were found in Finn Creek, but could not be measured since residues were below the levels of analytical accuracy. Techniques for measuring Sevin are not as precise as for DDT.

DDT concentrations ranged from a trace to 0.000060 p.p.m. during and after spraying on July 26 and 27, 1963. The range on July 28 was from a trace to 0.000020 p.p.m., and from a trace to 0.00030 p.p.m. on July 29. Measurable DDT persisted for 12 hours.

DDT residues in pre-spray samples of Silver salmon were 0.020 p.p.m. as compared to 0.550 p.p.m. following the spray. The levels of DDT residues in 1964 remained higher than the other study streams with fish tissues harboring 0.308 p.p.m.

Aquatic insects analyzed for DDT prior to spraying revealed only a trace, but post-spray samples contained 0.350 p.p.m.

It was observed during an accidental spraying of Finn Creek with Sevin that many aquatic insects were killed, but most of these were immediately eaten by the juvenile salmon and trout before they could be caught in the drift nets. Immediately after this accident the question was raised as to the possible harmful effects that Sevin-killed insects may have on small salmon. Consequently, approximately 100 Silver salmon fingerlings were seined and transported alive to the Grays River Salmon Hatchery to be kept under observation. An equal number of Silver salmon were collected from the control stream and also transferred to the hatchery. After 30 days of observation there was no significant mortality in either group.

Other Streams

Fink Creek, a stream draining an area sprayed with phosphamidon, was studied less intensively than the other streams. Live box studies revealed no mortality of fingerling salmon, crayfish and caddis fly larvae after spraying.

Tagged rock counts indicated that phosphamidon had no detectable effect on the young mayflies. Fink Creek drains into Jim Crow Creek near one of the lower sampling stations. Rock counts of insects made in Fink Creek above the confluence with Jim Crow Creek indicated a high population of young mayflies. In contrast, rocks below the confluence lacked young mayflies following the spraying of DDT. These observations clearly demonstrate the adverse effect that DDT has on young mayflies and the apparent lack of effect of phosphamidon.

In Williams Creek, just prior to spraying with DDT, insect counts were made on ten rocks. These same rocks were counted two days later following spraying and again when the last rock counts were made for all study streams. The newly hatched mayflies apparently were completely destroyed in this stream following the DDT spraying. Water samples indicated that a peak of 0.00030 p.p.m. DDT occurred. The September examinations showed rock counts as high as the pre-spray counts. Insect recovery followed the same patterns as set by other streams.

DISCUSSION

The biological indicators, fish and aquatic insects, demonstrated that the three chemical insecticides sprayed had different effects on the stream life.

Mayflies, particularly those in the first instar, were most seriously affected. The losses occurred when DDT concentrations ranged from 0.00010 to 0.00059 p.p.m. Baetids and Heptageniids appeared to be equally susceptible to these concentrations of DDT.

Stoneflies in the family Perlidae markedly decreased following the spraying of Sevin and DDT in Finn Creek. This was the only instance where stoneflies showed any departure from the normal population trends.

The relationship between DDT residues in fish and aquatic insects, and the latent effects to these biological organisms was not studied. There is good indication, however, that the level of residues found in live fish specimens in this study may not be harmful. Live aquatic insects contained a maximum concentration of 0.39 p.p.m. DDT. The significance of this is not known.

Several other aspects observed during the spray operation warrant discussion. The spray application by helicopter and the relationship with wind direction and velocity was of primary importance. Two separate observations served to point out that when the insecticide application was made on the downwind side of both Jim Crow and Finn Creeks, no adverse effects were noticed to any of the stream organisms. When spraying was carried out on the upwind side of the streams, there were measurable detrimental effects to certain families of aquatic insects.

Water samples in Jim Crow Creek contained 0.000085 p.p.m. DDT when the downwind side was sprayed as opposed to 0.000590 p.p.m. DDT when the upwind side was sprayed. Sevin was not detected in measurable quantities in Finn Creek to make comparisons. As spraying was done with wind velocities not exceeding five miles per hour, it was apparent that a higher degree of application control must be exercised when flights are made on the upwind side of the stream.

There was no detected outward migration of salmon or trout during the spray project, indicating that the sub-lethal amounts of various insecticides that entered the streams were tolerated

without the fish showing any avoidance reaction. No dead fish were caught in the Fyke nets in any of the test streams. The drift nets did not catch any dead insects since no massive insect kills occurred.

Recovery of small mayflies after the spraying was more rapid than expected. This was an indication that sufficient older mayfly nymphs had survived and emerged to become egg laying adults. This was supported by the results of the 1964 followup studies where population trends were similar to those shown prior to spraying in 1963.

Certain minor modifications of field techniques for future studies are suggested. A standardization of size and shape of rocks to be tagged for quantitative insect evaluation would be beneficial. The rocks with relatively flat surfaces appeared to be preferred to those that were oval. All rocks should be placed at a uniform depth with approximately the same current flowing over them for best results.

Stream bottom samples of insects should be collected from the same portion of each riffle sampled. A suggested portion would be the square meter starting two feet below the head of a riffle. Rock and riffle size should be as similar as possible for best comparisons. A fixed time(ten minutes) for picking insects off of nets would assist in standardization of samples.

Drift nets with very fine mesh that could catch first instar mayflies could supply additional information for a precise evaluation of losses. Keeping a net such as this free of debris could be a problem and frequent maintenance might be required.

Water sampling periods should be based on a predetermined time of passage for a given block of water. This is necessary to insure that sampling is not terminated while insecticides still remain in the stream. Sampling should begin just prior to spraying and be carried out until the calculated time of passage has elapsed. Insecticide increases, peaks and decreases can then be plotted and correlated with any mortalities observed in the streams.

Credit must be given to the numerous state, federal and private agencies who worked cooperatively in the planning and the actual field studies. It was necessary to incorporate various professional disciplines in this study to obtain the best possible evaluation of the problem at hand. Good communications between the various operation groups facilitated accomplishments of the fresh-water stream studies.

CONCLUSIONS

A comparison was made of the inimical effects to stream life following spraying with DDT, Sevin and phosphamidon. DDT and Sevin were found to cause decreases in mayfly populations, particularly those that were newly hatched. In one case, after Sevin and DDT were sprayed, Perlidae stonefly populations declined. Phosphamidon, on the other hand, did not cause noticeable aquatic insect population declines even though the spray was applied directly over the creek.

In streams where marked decreases of aquatic insects were observed, recovery to pre-spray levels occurred within two months. Aquatic insect populations in the 1964 followup studies, in general, were similar to those prior to spraying in 1963.

No fish or crayfish mortalities attributable to the sprays were observed in any of the test streams. There was no avoidance reaction or downstream migration of either Silver salmon or trout fingerlings because of the sprays. A question still remains in regard to what effects, if any, the sub-lethal doses of DDT and Sevin may have on the reproductive organs of the fish that were in the streams during the spraying, and how this might be reflected on future salmon and trout runs.

The application of chemical insecticides by helicopter in this spray operation caused less damage to stream life than application by fixed wing aircraft in some of the previously cited operations. The degree of control maintained with helicopters helped to keep the insecticides away from the streams. Consequently, only temporary aquatic insect damage was experienced. This emphatically points out that, if spraying forests with hazardous insecticides has to be done, it can be accomplished without causing long-lasting effects to the aquatic insect and fishery resources provided that proper planning and flight control are designed and carried out to give adequate protection to the streams.

TABLE 1. AQUATIC INSECT OCCURRENCE IN STUDY STREAMS, WILLAPA LOOPER INFESTATION CONTROL PROJECT, SOUTHWEST WASHINGTON

Aquatic Insects	Clearwater Creek Average Number of Insects per Square Meter*						
	1963				1964		
Order & Families	June 5	July 3	July 26	Aug. 9	July 1	Aug. 12	Sept. 17
Ephemeroptera							
Baetidae	49	27	18	13	61	13	4
Heptageniidae	29	23	5	7	26	8	28
Plecoptera							
Perlidae	13	22	29	40	8	23	28
Chloroperlidae	3	1	0	0	0	**	0
Perlodidae	**	**	0	0	0	2	2
Trichoptera							
Hydropsychidae	9	7	1	3	5	7	3
Rhyacophilidae	0	**	0	1	0	2	**
Psychomyiidae	1	4	2	6	7	3	**
Diptera							
Chironomidae	0	0	0	0	**	0	0
Simuliidae	0	1	**	8	0	2	5
Tipulidae	1	0	**	1	**	**	**
Coleoptera	5	**	0	2	**	**	**

Aquatic Insects	Davis Creek Average Number of Insects per Square Meter*						
	1963				1964		
Order & Families	June 5	July 18	July 25	July 30	July 2	Aug. 13	Sept. 18
Ephemeroptera							
Baetidae	17	22	4	5	11	1	0
Heptageniidae	36	5	1	1	14	1	1
Plecoptera							
Perlidae	6	14	14	19	4	28	32
Chloroperlidae	14	3	2	0	4	0	1
Perlodidae	3	**	0	**	0	1	4
Nemouridae	**	0	**	**	1	1	0
Paraperlinae	0	0	0	0	**	**	0
Trichoptera							
Hydropsychidae	0	1	2	2	**	3	2
Rhyacophilidae	0	1	0	**	0	0	0
Psychomyiidae	2	2	1	**	2	**	0
Diptera							
Chironomidae	0	**	0	0	0	8	**
Simuliidae	6	5	**	0	2	3	3
Tipulidae	3	1	6	7	**	3	4
Dixidae	**	0	0	0	0	0	0
Coleoptera	0	0	0	0	**	0	0

* Approximately a square meter.
**Insects present but insufficient numbers for an average.

TABLE 1. (Continued)

Jim Crow Creek
Average Number of Insects per Square Meter*

Aquatic Insects	1963			1964		
Order & Families	June 7	July 3	July 15	July 2	Aug. 13	Sept. 18
Ephemeroptera						
Baetidae	51	41	**	57	12	22
Heptageniidae	28	12	1	10	1	1
Ephemeridae	0	0	0	0	0	1
Plecoptera						
Perlidae	1	5	14	**	16	4
Chloroperlidae	1	0	11	1	3	**
Perlodidae	3	0	0	1	**	1
Nemouridae	0	2	9	0	0	0
Peltoperlidae	0	3	0	0	0	0
Trichoptera						
Hydropsychidae	**	2	0	**	5	6
Rhyacophilidae	**	0	0	0	0	0
Psychomyiidae	3	1	1	0	**	0
Limnephilidae	1	**	**	0	0	0
Philopotamidae	0	0	0	1	0	0
Diptera						
Chironomidae	5	24	0	3	0	1
Simuliidae	7	2	0	3	4	1
Tipulidae	1	**	1	1	5	**
Rhagionidae	1	**	0	0	0	0
Coleoptera	2	1	0	0	**	0

Finn Creek
Average Number of Insects per Square Meter*

Aquatic Insects	1963					1964		
Order & Families	June 4	July 9	July 23	July 25	Aug. 1	July 1	Aug. 12	Sept. 17
Ephemeroptera								
Baetidae	36	49	31	52	54	149	105	19
Heptageniidae	56	19	13	7	23	71	13	4
Plecoptera								
Perlidae	18	28	7	11	5	4	28	47
Chloroperlidae	0	3	0	0	0	1	8	2
Perlodidae	1	1	0	0	0	**	0	0
Nemouridae	0	**	0	0	0	0	0	0
Trichoptera								
Hydropsychidae	8	7	3	2	0	0	**	2
Rhyacophilidae	0	0	**	**	3	**	**	1
Psychomyiidae	4	18	11	9	5	8	2	1
Limnephilidae	**	**	0	**	0	0	0	0
Diptera								
Chironomidae	0	**	**	0	1	**	**	0
Simuliidae	2	1	1	0	0	4	1	2
Tipulidae	0	3	1	1	**	0	4	3
Coleoptera	3	0	0	2	**	1	1	2

* Approximately a square meter.
**Insects present but insufficient numbers for an average.

TABLE 2. CONCENTRATIONS OF DDT AND ITS METABOLITE DDE IN JUVENILE SILVER SALMON AND AQUATIC INSECTS, 1963

Stream	Pre-spray			Post Spray			Pre-spray			Post Spray		
	Silver Salmon						Aquatic Insects					
	Parts per Million						Parts per Million					
	DDT	DDE	Total	DDT	DDE	Total	DDT	DDE	Total	DDT	DDE	Total
Clearwater Creek (Control)	T*	.01	.01+				T	T	T			
Finn Creek	.009	.011	.020	.43	.12	.55	T	T	T	.20	.15	.35
Davis Creek	.01	.007	.017	.018	.008	.026	.01+	T	.01+	**		
Jim Crow Creek	T	.01	.01+	.89	.18	1.07	T	T	T	.32	.07	.39

* T = less than 0.001 p.p.m.
** insufficient amount of insects for analysis.

TABLE 3. CONCENTRATIONS OF DDT AND ITS METABOLITE DDE ON ONE AND TWO-YEAR CUTTHROAT TROUT, 1964

Stream	Parts per Million		
	DDT	DDE	Total
Clearwater Creek	.015	.004	.019
Finn Creek	.081	.227	.308
Davis Creek	.010	.003	.013
Jim Crow Creek	.008	.028	.036
Nemah Hatchery (Silver salmon)	.023	.012	.035

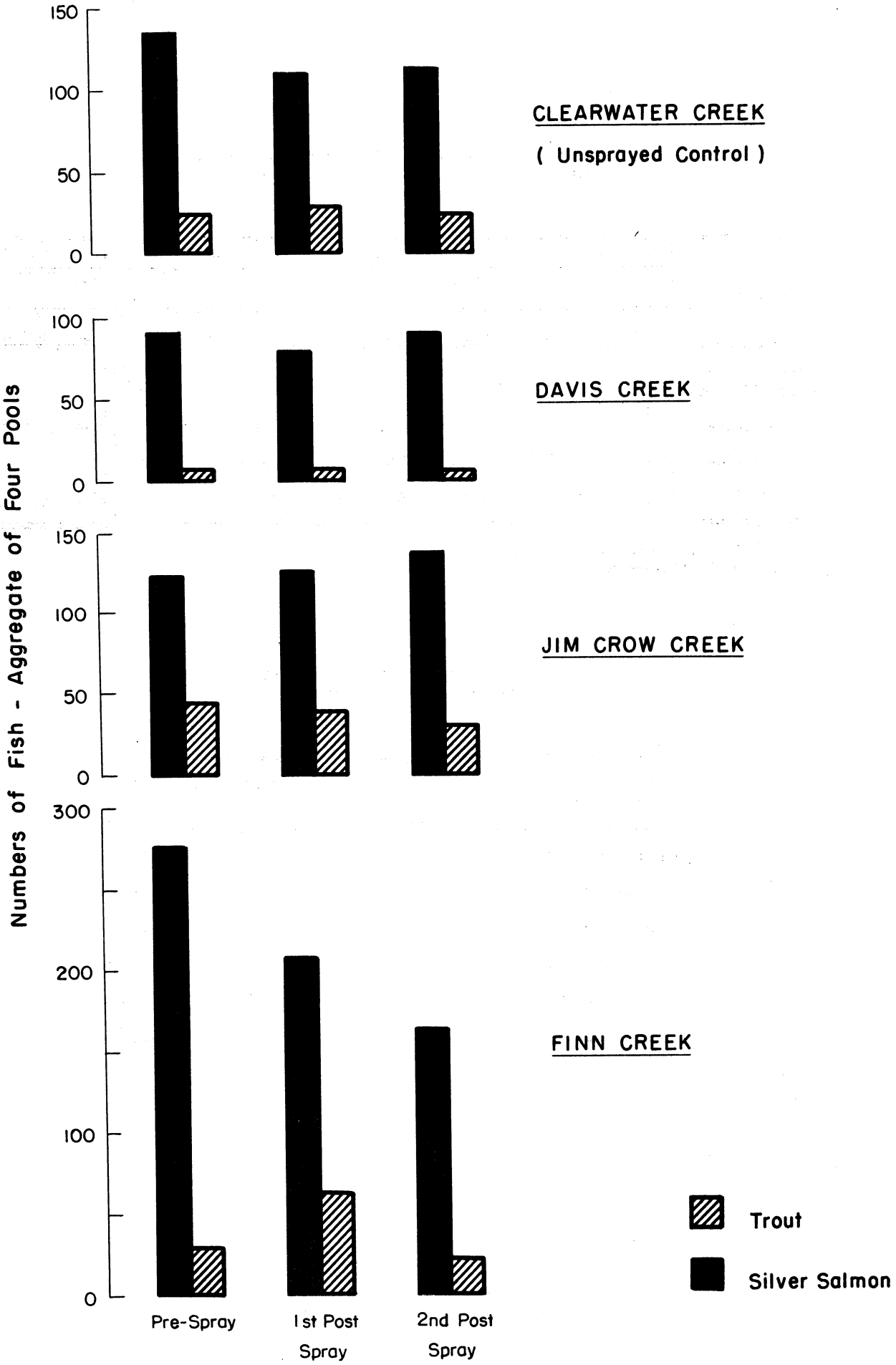

Figure 1. Population trends of Silver salmon, Cutthroat and Steelhead trout juveniles before and after forest spraying, summer 1963.

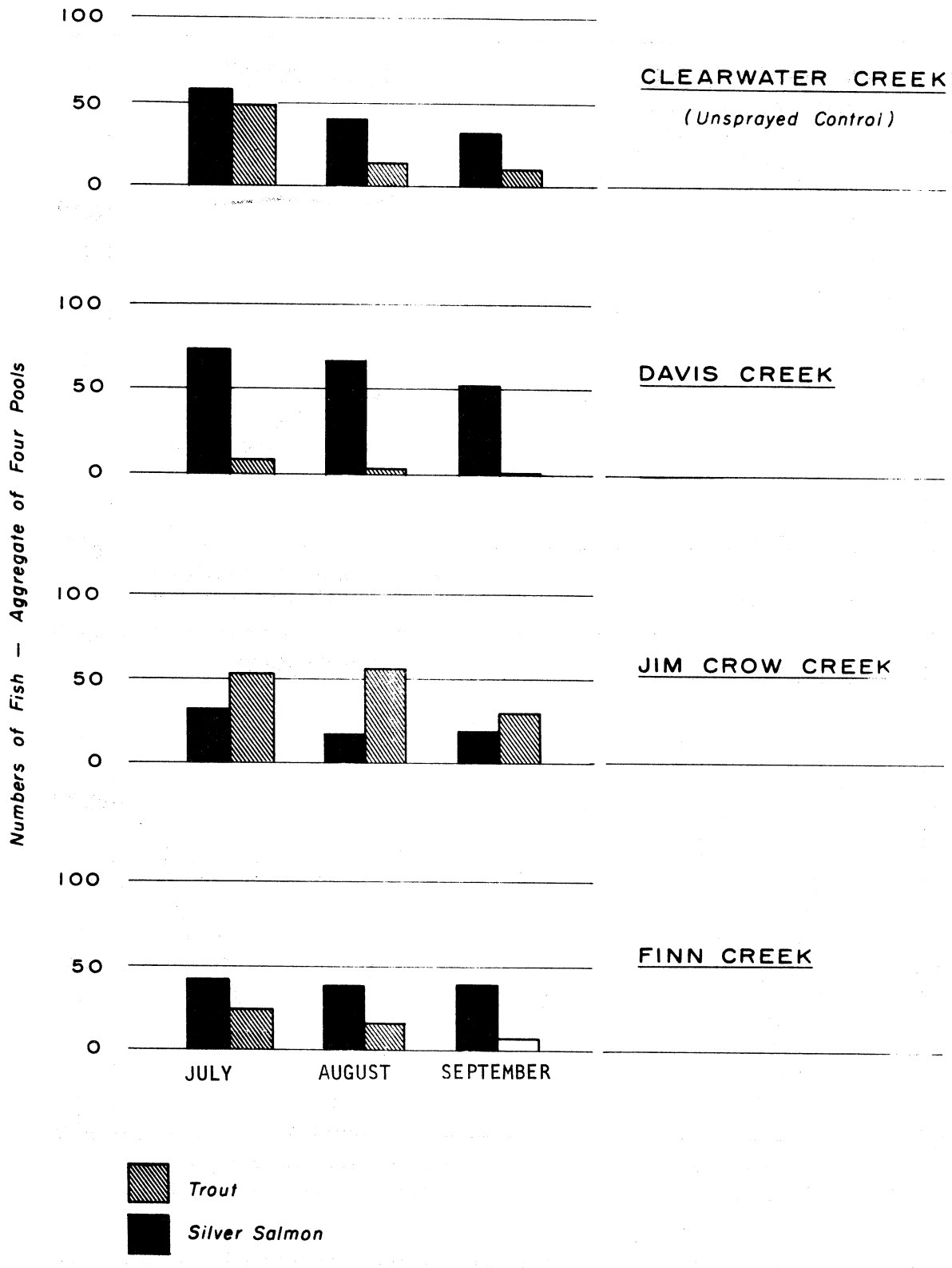

Figure 2. Population trends of Silver salmon, Cutthroat and Steelhead trout juveniles one year after spraying, July, August and September, 1964.

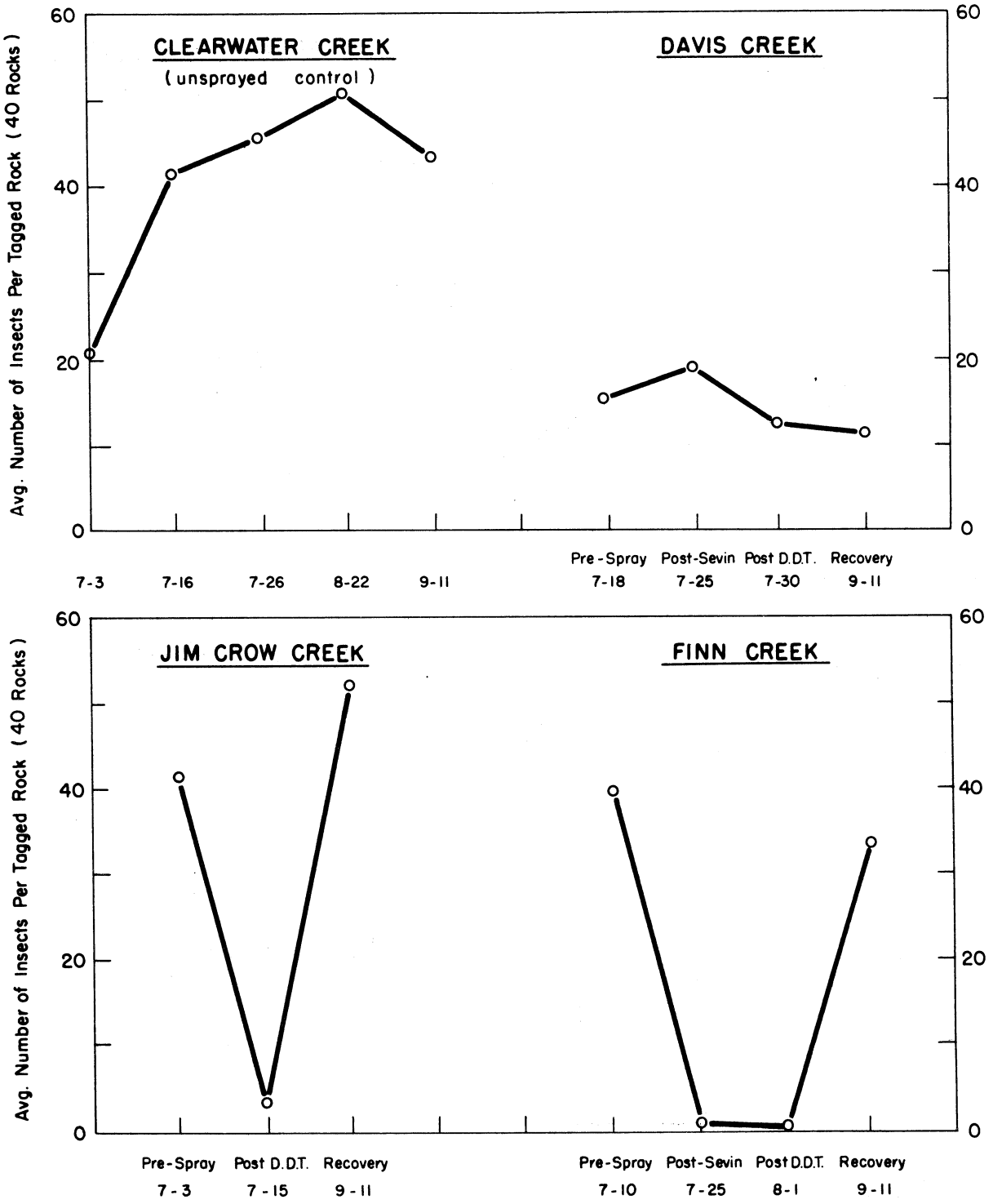

Figure 3. Population trends of aquatic insect nymphs and larvae before and after forest spraying, tagged rock studies, summer, 1963.

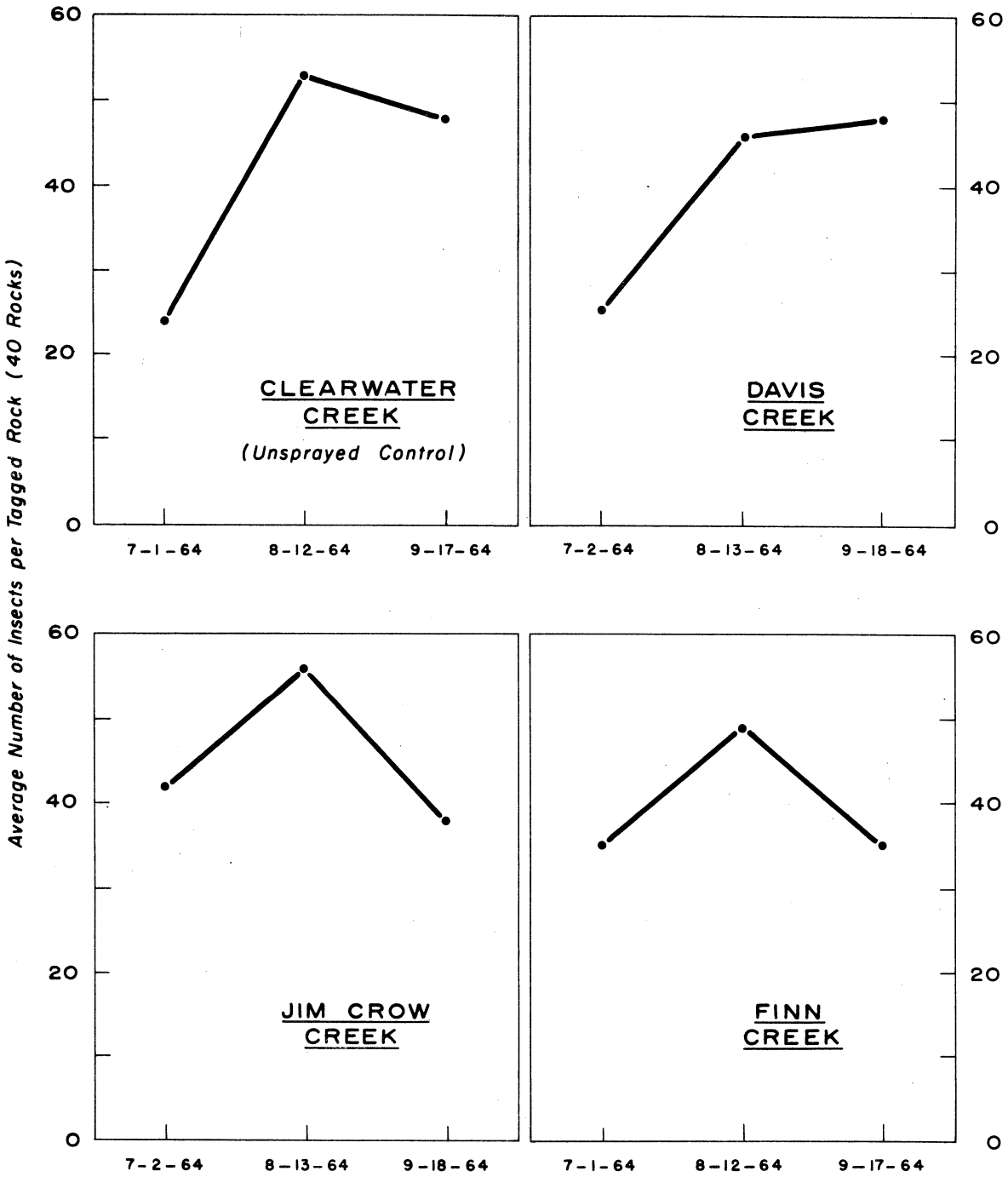

Figure 4. Population trends of aquatic insect nymphs and larvae one year after spraying, summer, 1964.

FIGURE 5

PARTS PER MILLION

DDT VALUES

DAVIS CREEK
.000200
.000150
.000100
.000050

WILLIAMS CREEK
.000350
.000300
.000250
.000200
.000150
.000100
.000050

FINN CREEK
.000350
.000300
.000250
.000200
.000150
.000100
.000050

BEAR RIVER
.000350
.000300
.000250
.000200
.000150
.000100
.000050

JIM CROW CREEK
.000600
.000550
.000500
.000450
.000400
.000350
.000300
.000250
.000200
.000150
.000100
.000050

6 am 12 6 pm 6 12 6 6 12 6 6 12 6 4 8 12 4 8 4 8 12 4 8 6 12 6 4 am 8 12 4 8 pm 12 4 8 12 4 8 12 4 8 12 4 8 12 4 am 8 12 4 8 pm 12 4 8 12 4 8 12 4 8 12 6 12 6 6 12 6 6 12 6 6 am 12 6 pm

JUN 18 JUL 2 JUL 5 JUL 6 JUL 9 JUL 10 JUL 21 JUL 24 JUL 25 JUL 26 JUL 27 JUL 28 JUL 29 JUL 30 AUG 1 AUG 2 SEPT 5 SEPT 11

TIME AND DATE

DDT VALUES IN FIVE STREAMS
JUNE – SEPT., 1963

Southwest Washington Hemlock Looper Control Project

▨ TIME OF SPRAY
● DDT VALUE LEVEL
○ SAMPLE ANALYZED. (VALUES LESS THAN .000050 PARTS PER MILLION NOT PLOTTED)

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EFFECTS OF SPRAYING ON TREE MORTALITY AND DEFOLIATION

P. G. Lauterbach [1/]

The objective of the 1963 Willapa hemlock looper project was to prevent or minimize tree killing and additional defoliation of hemlock stands by the hemlock looper, with a minimum of damage to the other resources of the region.

Because Sevin achieved generally unsatisfactory control of the loopers and DDT achieved excellent control in tests by the State of Washington and the U. S. Forest Service, Weyerhaeuser Company and Crown-Zellerbach decided to spray 14,810 acres of the heaviest infestation areas that were generally inacessible. One area of heavy infestation near Willapa Bay (Sunshine Point) was sprayed with Sevin, and Long Island was unsprayed except for one small area sprayed with Bacillus.

To follow the mortality and defoliation, aerial color photos were taken in June 1963 before the control projects were started. These same areas were photographed in August 1964 with both aerial Ektochrome and Ektochrome infrared aero film. These trees on the photographs were carefully examined with a mirror stereoscope. Ground checks of interpreted photographs showed good relationship of photo count to field count of number of dead and heavily defoliated trees.

Following are typical examples of photo counts in unsprayed area on Long Island, on Sunshine Point which was sprayed with Sevin, and Finn Creek, which was sprayed with DDT in oil:

Treatment	Location	1963 Photo Count of Heavily Defoliated Trees [2/]	1964 Photo Count of Heavily Defoliated and Killed Trees	Percent Change
No control	Long Island	17	58	+241
Sevin	Sunshine Point	31	176	+468
	Sunshine Point	5	31	+520
DDT	Finn Creek	141	62	- 57

In DDT Spray areas examined on the ground in 1964 many of the heavily defoliated trees were recovering from the earlier defoliation and putting on new growth. The tops of many of these trees were killed, but the trees will probably remain alive to allow orderly harvest of timber with minimum tree mortality.

DDT RESIDUES ON SWORD FERN

Norman E. Johnson [3/] William H. Lawrence [4/]

Following the report to the Washington State Game Department that fat samples from elk and deer harvested in the vicinity of the Willapa hemlock looper spray project area contained DDT, it was decided that forage from the area should be analyzed for DDT. One year after the spray project new and old sword fern fronds were collected from areas known to receive high, moderate, low and zero amounts of DDT, as determined by Johnson in 1963 [5/]. Sword fern was selected for sampling as it is an important forage species for big game that has persistent foliage.

Residue analyses were made by Dr. I. Gauditz under the direction of Dr. John Rediske, plant physiologist, Weyerhaeuser Company Forestry Research Center. The procedure was as follows:

1/ Project Forester, Weyerhaeuser Forest Research Center, Centralia, Washington.
2/ No killed trees.
3/ Forest Entomologist, Weyerhaeuser Forest Research Center, Centralia, Wash.
4/ Forest Wildlife Biologist, Weyerhaeuser Forest Research Center, Centralia, Wash.
5/ Johnson, Norman E. 1963. Mortality of hemlock looper larvae following spraying with DDT. Weyerhaeuser Co. Forestry Research Note No. 55. 10 pp.

Fifty gram samples were extracted with benzene; and aliquot of the filtered extract, equivalent to 5 grams of fern, was passed through a Nuchar-Attaclay column eluting the DDT with ether-acetone mixture. A fraction of the eluate was evaporated to dryness and the remaining residue redissolved in 50 microliters of n-hexane and of this solution, one microliter was injected into a gas-liquid chromatograph equipped with an electron capture detector. Under the conditions used here, an accuracy of 2 nanograms per gram can be obtained.

A test of recovery rate was made using samples of fern from areas not sprayed with DDT. These samples were fortified with 40 nanograms of p,p' DDT per gram of tissue and analyzed as described above. Recoveries for two samples were 56 and 63 percent.

Table of Results*

Sampling Location	Original Spray Level	ng p,p' DDT/g Old Fronds (1963 growth)	ng p,p' DDT/g New Fronds (1964 growth)
Williams River S 17, T 12N, R 9W (Along Road)	High	45.6	24.5
(Within Stand)	High	50.0	15.0
Finn Creek S 28, T 12N, R 9W (Edge of Stand)	Moderate	19.7	20.5
(Within Stand)	Moderate	33.4	15.3
Finn Creek S 29, T 12N, R 9W (Within Stand)	Low	22.8	5.0
(Along Stream)	Very Low	2.7	12.0
Clearwater Creek	None	2.7	0.0

* Results are stated as nanograms of p,p' DDT per gram of fresh sword fern. They have been corrected for a 60 percent average recovery rate but not for other DDT isomers.

We do not know whether the DDT residues found on new (1964) fern fronds was surface contamination from the hemlock overstory or whether it was actually in the vascular system indicating a systemic residue.

The residue level on fern is only a small fraction of that calculated to be present following spraying. Although foliage samples were not analyzed at the time of spraying, our calculations suggest a maximum residue level of 197 ppm. (based on the application rate of 3/4 pounds of DDT per acres with 50 percent recovery at ground level and a weight of fern frond of 0.138 grams per square inch). It was this level of residue that game animals were subjected to which resulted in the increase of DDT in deer and elk. The highest level on ferns reported here is 50 nanograms per gram or 50 parts per billion; this is about 1/4000 of the amount that probably would have been found on the fern shortly after spraying.

It is concluded that these residues will not add significantly to the low residues recently reported in deer and elk fat by the Pesticide Chemicals Research Branch of the ARS (Report # PCY-64-18).

ENTOMOLOGY RESEARCH DIVISION
PESTICIDE CHEMICALS RESEARCH BRANCH
YAKIMA, WASHINGTON

REPORT OF RESIDUE ANALYSIS

Date: September 15, 1964 Report No. PCY-64-18

Sample of: Adipose Tissue from Game Animals

Analyze for: DDE and TDE and DDT (both isomers)

Submitted by: Cooperative with Department of Game, State of Washington

Summary

Tissue samples from eight deer and two elk killed in August of 1964 within or adjacent to the areas sprayed in 1963 were analyzed. The eight deer contained an average combined residue of 0.098 part per million with a range of 0.037 to 0.190 p.p.m. The two elk samples contained a combined residue of 0.180 and 0.260 p.p.m.

Following the application of 0.75 pound of DDT per 1½ gallons of diesel oil per acre in July of 1963 adipose tissue samples were collected during the 1963 hunting season.

Tissue samples from 12 deer killed in the fall of 1963 contained an average combined residue of 2.73 p.p.m. with a range of 0.26 to 10.48 p.p.m. Eight of these deer were killed either within the sprayed area or within 1 mile of the sprayed area.

Tissue samples from 25 elk killed in the fall of 1963 contained an average combined residue of 2.99 p.p.m. with a range of 0.09 to 10.18 p.p.m. Seventeen of these elk were killed either within the sprayed area or within 1 mile of the sprayed area.

Adipose tissue samples from 3 deer and 34 elk killed in Pacific and Wahkiakum Counties of the State of Washington in 1962 contained an average combined DDE, TDE and DDT residue of less than 0.1 p.p.m.

This study would not have been possible without the excellent cooperation of the Department of Game of the State of Washington and of the game biologists of this department.

Date: April 13, 1965 Report No. PCY-65-17

Summary

Tissue samples from six deer and ten elk killed [1/] in or adjacent to the area sprayed in 1963 with 0.75 pound of DDT per one and one-half gallons of diesel oil per acre in July 1963 were analyzed.

The total DDT content (DDE, TDE + o,p'-DDT, p,p'-DDT) of the adipose tissue of six deer ranged from 0.030 to 0.070 and averaged 0.044 p.p.m. The total DDT content of ten elk ranged from 0.039 to 0.440 and averaged 0.165 p.p.m. All are under the tolerance of DDT for domestic animals which is 7.0 p.p.m.

1/ Taken during the hunting season--October and November, 1964.

A TEST OF INSECTICIDES FOR CONTROL OF THE WESTERN HEMLOCK LOOPER

Norman E. Johnson [1/] P. E. Buffam [2/]

Following the poor showing of the insecticide carbaryl (Sevin) on the 1963 Willapa hemlock looper control project, Weyerhaeuser Company and the U. S. Forest Service conducted a small-scale test of 10 insecticides for control of the looper.

Essentially, the procedure was to place 50 looper larvae on small caged branches which were then sprayed with several concentrations of the 10 insecticides. Counts of dead and dying loopers were made at 2, 24 and 96 hours after spraying. Using the average percent mortality for all concentrations, the insecticides in order of increasing effectiveness are: (1) water control, (2) Meta-Systox-R, (3) diesel oil, (4) Dimethoate, (5) carbaryl (Sevin), (6) Phosphamidon, (7) DDT in oil, (8) Malathion, (9) Guthion, (10) Pyrethrum, (11) Endosulfan and (12) DDT in water.

Meta-Systox-R, Dimethoate, carbaryl and Phosphamidon were considered markedly inferior to the remaining insecticides.

Tests conducted at the Pacific Southwest Forest and Range Experiment Station at Berkeley, California likewise showed that carbaryl gave poor control of the hemlock looper [3/]. A related insecticide, Zectran, gave excellent control in the California tests.

1/ Forest Entomologist, Weyerhaeuser Forest Research Center, Centralia, Wash.
2/ Forest Entomologist, U. S. Forest Service.
3/ Memorandum from Dr. A. D. Moore, Pacific Southwest Forest and Range Experiment Station, Berkeley, California.